

DIN 6700 – 5 (Stand 2002-05)

ICS 25.160.01; 45.060.01

Welding of railway vehicles and parts – Part 5: Quality requirements
Soudage des véhicules ferroviaires et des pièces – Partie 5: Exigences de qualité

Preface

This standard is given by the AA 3.4 “Welding technique” of the norm committee railway vehicles (FSF).

Welding is an essential process for the manufacturer of railway vehicles and their parts.

Railway vehicles in the sense of this standard are defined in DIN 25003.

In this norm series the requirements for the special process „welding“ are being met. Basis of these requirements are the welding technological basic norms with consideration of the special requirements for the manufacture of railway vehicles.

Part 1: deals with the basic concepts and basic rules

Part 2: contains the requirements for the qualification of the welding plants

Part 3: deals with the construction instruction

Part 4: deals with the carrying out instruction

Part 6: contains the instructions for materials, welding fillers, welding procedures and the welding technological documents.

Continuation page 2 to 22

1 Area of Application

This norm comprises the quality requirements for welding points of railway vehicles and vehicle parts. In this norm are determined the welding seam quality classes and the dependability of the welding processes and quality requirements.

For welding procedures not mentioned the quality requirement must be agreed between the customer and the manufacturer.

2 Normative instruction

This norm contains by way of dated and undated instructions determinations from other publications. These normative instructions are cited in the text at respective places and the publications are given following it with dated instruction, later changes or re-working of these publications belong to it only if they have been included owing to a change or reworking. For undated instructions the last edition of the respective publication is valid (including modifications).

- DIN 1910-2 Welding – Welding of metals procedure
- DIN 6700-1 Welding of railway vehicles and -parts – Part 1: basic concepts, basic rules
- E DIN 6700-3 Welding of railway vehicles and -parts – Part 3: Instruction for manufacturer
- E DIN 6700-6 Welding for railway vehicles and –parts Part 6: material welding fillers, welding procedure, welding technological documents
- DIN 8528-1 Weldability – metallic materials, concepts
- E DIN 32518-2 Test on resistance welding joints – Torsion test on resistance spot welding joints
- DIN 50124 Testing of metallic materials; shear tension test on spot joints, projecting joints by resistance welding and fusion welding
- DIN EN 288-3 Requirements and recognition of welding procedure for metallic materials – Part 3: Welding procedures for arc welding of steel, German version EN 288-3-1992
- DIN EN 895 Destructive test of welding joints of metallic materials – Tensile test. German Version EN 895:1995
- DIN EN 910 Destructive tests on welds in metallic materials – Bend tests
- DIN EN 970 Non-destructive examination of fusion welds – Visual examination
- DIN EN 10025 Hot rolled products of non-alloyed steel – Technical delivery conditions / (Contents modification A1: 1993). German Version EN 10025:1990
- DIN EN 10130 Cold rolled flush products of soft steel for cold conversion (Shaping) – Technical supply conditions. German Version EN 10130:1991
- DIN EN 14555 Arc stud welding of metallic materials
- DIN EN 24063 Welding, brazing, soldering and open joint brazing of metals – List of procedure and order number for drawing presentation (ISO 4063:1990); German version EN 24063: 1992
- DIN EN 25817 Arc welding joints for steel – Guidelines for the validity groups of irregularities, unevenness
- DIN EN 30042 Arc welding joints for aluminium and its welding suitable joints. Guidelines for the validity groups of unevenness (ISO 10042:1992); German version EN 30042:1994
- DIN EN ISO 6520-1 Classification and explanation of unevenness for fusion welding on metals – Fusion welding
- DIN EN ISO 6520-2 Classification and explanation of unevenness for fusion welding on metals – Pressure welding
- DIN EN ISO 13919-1 Welding – electron – and laser beam – welding joints – leading instructions for validity groups of unevenness. Part 1: steel (ISO 13919-1:1996); German version EN ISO 13919-1:1996
- DIN EN ISO 13919-2 Welding – electron – and laser beam – welded joints – Guidance on quality levels for imperfections – Part 2 Aluminium and its weldable alloys
- DIN ISO 10447 Welding – Rolling – and chisel test of resistance –spot – projection and roller seam welding – conform to ISO 10447:1991
- DVS 1616 Selection of materials for welding application for railway-vehicles and their components
- DVS 2923 Resistance spot welding of steel and aluminium materials in the manufacture of railway vehicles

3 Concepts

For these norms the stated concepts of DIN 6700-1 are valid.

4 Classification of the welding quality classes in this dependency of the permissible unevennesses

The welding seam quality classes (SGK) are classified depending of the permissible unevenness into 3 groups:

- welding seams with special requirements SGK 1
- welding seams with high or medium requirements SGK 2.1
SGK 2.2
SGK 2.3
- welding seams with medium or low requirements SGK 3

SGK 2.1 to SGK 2.3 are carried out in according to instructions of E DIN 6700-3, table 1..

5 Welding seam quality classes and welding procedure

In consideration of the structure of the part, the production- and test possibility as well as the manufacture seam quality the application of the welding seam quality classes is permissible according to table 1 for the separate welding procedures.

Table 1: Permissible welding seam classes for welding joints in dependency of the welding procedure

Ser. No.	Welding procedure to DIN EN 24063 and DIN 1910-2	Welding seam quality classes					See section
		1	2.1	2.2	2.3	3	
1.	Fusion-welding						6.1
1.1	Arc welding-, Radiation- and Gas- fusion welding						6.1.1
1.1.1	111 (E)	x	x	x	x	x	6.1.1
1.1.2	12 (UP)						
1.1.3	15 (WPL)						
1.1.4	114 (MF)						
1.1.5	131 (MIG)						
1.1.6	135 (MAG Massive wire)						
1.1.7	136 (MAG Filler wire)						
1.1.8	141 (WIG)						
1.1.9	751 (LA)						
1.1.10	311 (G)						
1.2	Studwelding ^a 78 (BH, BS)	-	-	-	x	x	
2.	Resistance welding						
2.1	21 (RP)	-	x	-	x	x	
2.2	23 (RB)	-	-	-	x	x	
2.3	22 (RR)	-	x	-	x	x	
2.4	225 (RFS)	-	x	-	x	x	
2.5	24 (RA)	x	x	x	-	x	
3.	Other welding procedures	SGK will be agreed between customer and manufacturer					

6 Welding seam quality classes and quality requirements

Fusion welding joints

6.1 Fusion welded joints

6.1.1 Arc welding – radiation and gas fusion joints

6.1.1.1 General requirements

The general requirements are valid in according to the relevant welding seam quality class and the test extent to **table 2**.

6.1.1.2 Quality requirements

6.1.1.2.1 Arc welding fusion welding joints with steel

The quality requirements for the arc fusion welding on steel (inclusive cast steel) can be found in **table 3**.

Table 3 consists of the classification of irregularities of validity groups to DIN EN 25817 with additional determination.

6.1.1.2.2 Arc fusion welding joints for aluminium and aluminium alloys

The quality requirements for fusion welding joints on aluminium and aluminium alloys can be found at **table 4**.

Table 4 consists of the classification of irregularities to DIN EN 30042 with additional determinations.

6.1.1.2.3 Arc fusion welding joints on other materials

For arc fusion welding of other materials the requirements of **table 3** respectively **table 4** have to be applied.

Table 2: General requirement and test extent for arc-radiation and gas fusion welding joints

Welding seam quality class (SGK)		1	2.1	2.2	2.3	3						
Permissible sort of seams		Only butt seams with full cross-section joints on T-and butt joints	permissible on all seams									
Weldability of the parts to DIN 8528-1	Suitable of material	good	good to limited									
	Welding safety of construction	good	good to normal									
	Welding possibility of manufacture	very good	good to normal									
Start- and run out metal with buttseams		necessary	Only necessary for high dynamic load and high safety requirements	Event design requirements								
		Up $t > 8$ mm permissible as base with $t > 8$ mm adaptation at seam preparation necessary										
Welding bath safety feature		Padding permissible, supplement (remarking bath safety) not permissible	Supplement only permissible if shown on drawing				Permissible					
Counter position (backing position ^a		Necessary ^b	Only required if shown on drawing ^b				Not required					
		Prior to welding the counter position, root position must be worked out ^{c, d, f}										
Feature characteristics		The feature is permissible on a constructive marked place by using an impact stamp										
Test extend		100 % (Visual test + NDT) ^e		100 % Visual test and up to 10 % NDT ^e	100 % Visual test							
^a For welding procedure 15 (WPL), 751 (LA) and 76 (EB) not required.			^e For butt seam joints: X-ray test (RT), supersonic (UT)-or surface cracks (PT; MT)- test respective work tests prior to manufacture start only with agreement to the client. Event. process monitoring with agreement to the client.									
^b Can be replaced by welding bath safety feature (not supplement)			<u>For T-joints:</u> Fillet welds: surface cracks test (magnetic inspection (MT) or penetration test (PT)), event. work tests.									
^c Not required when faultless seam has been established by procedure test from user (for inst. at UP-welding seam/counter seam position)			HV-seam: work tests (macro) and PT, event. Supersonic (UT) with agreement to the client.									
^d For SGK 2.2 and 2.3 the working out of the root position is not required for seams not welded through (for inst. Sealing			HY-seam: work tests (macro) and PT									
			^f Supplement is allowed, if seam-geometry is equal									

seam for Y-Seams)

Table 3: Quality requirements for arc-fusion welding joints on steel

Ser.no.	Order No. to DIN EN ISO 6520-1	No. to DIN EN 25817	Irregularities Description	Welding quality classes				
				1	2.1	2.2	2.3	3
Validity groups to DIN EN 25817; Deviations								
1	100 104	1 2	Crack Crater crack	B		B		C
2	2011	3	Gas pore	B		B		C
	2012	3	Uniformly distributed porosity			(A ≤ 2%) ^a		A ≤ 4%
	2014	3	Linear porosity					
3	2017	3	Surface pores	Not permissible		B		C
4	2013	4	Clustered porosity	B		B		C
5	2015	5	Elongated cavity	Not permissible		B		C
	2016	5	Worm- hole			(I ≤ a rsp. s) ^b		
6	300	6	Solid inclusions	B (I ≤ a rsp. s)		B (I ≤ a rsp. s)		C
7	3042	7	Copper inclusion	B		B		C
8	401	8	Lack of fusion	B		B		D
9	402	9	Lack of penetration (also for Y- and HY-seam)	B		B		C
10	617	10	Incorrect root gap for fillet welds	Inapplicable		B (front length edge at fillet welds to seize firmly)		C
11	5011 5012	11	Continuous undercut Intermittent undercut	Not permissible		B Only short irregularities permissible h ≤ 0,1t ≤ 0,5mm ^c		C
12	502 503	12 13	Seam super elevation at Excess weld metal Excessive convexity	B (max. 3 mm)		C (at ≤ 3 mm local excess permissible)		D (at ≤ 3 mm local excess permissible)
13	5214	14	Excessive throat thickness	Inapplicable		C (at ≤ 3 mm local excess permissible)		D (at ≤ 3 mm local excess permissible)

Table 3 (continued)

Ser. no	Order No. to DIN EN ISO 6520-1	No. to DIN EN 25817	Irregularities Description	Welding quality classes				
				1	2.1	2.2	2.3	3
Validity groups to DIN EN 25817; Deviations								
14	5213	15	Insufficient throat thickness	Inapplicable	C (on 100 mm reference length is a_{nom} to be achieved centrally)			C
15	504 5041	16 17	Excess penetration Local excess penetration (only butt weld)	B (only with soft transition through grinding backing up or special welding filler)				C
16	507	18	Linear misalignment	B	C			D
17	509/511	19	Sagging/Incomplete filled groove	B	C			D
18	512	20	Excessive asymmetry of fillet weld	Inapplicable	C			D
19	515 5013	21	Root concavity Shrinkage groove (butt weld)	Not permissible	Only short irregularities permissible $h \leq 0,1 t \leq 0,5$ mm			C
20	506	22	Overlap	B	B			C
21	2025	None	End crater pipe	Not permissible	$h \leq 0,5$ mm (without sharp transition)			Permissible
22	517	23	Poor restart	B	B			C
23	601	24	Stray arc	Outside welding gap not permissible				
24	602	25	Spatter	Not permissible	At parts with paint not permissible. Outside painted surfaces permissible at times, but not with stainless steel (or surfaces must be acid)			
25	-	26	Various irregularities a) Sum of pores, porosity, gas channel, hole pore, worm hole and all firm inclusions (No. 3 - 7 to DIN EN 25817) b) Sum of other irregularities	A $\leq 1\%$	A $\leq 2\%$ on projection area of the X-ray picture or fracture area		A $\leq 4\%$	B
<p>a A = Area of irregularity about 100 mm seam length</p> <p>b l = Length of irregularity; a = Nominal measure of fillet weld thickness; s = Nominal size of butt weld thickness</p> <p>c h = Size of irregularities</p>								

Note: HV- and DHV- welding seams on T-Joints are butt welds

Table 4: Quality requirements for arc-fusion welding joints on aluminium and aluminium-alloys

Ser. No	Order No. to DIN EN ISO 6520-1	No. to DIN EN 30042	Irregularities Description	Welding quality classes				
				1	2.1	2.2	2.3	3
Validity groups to DIN EN 30042; Deviations								
1	100 104	1 2	Crack Crater crack	B		B		C
2	201 2011 2012 2014	3 4 5 None	Gas cavity Gas pore Uniformly distributed porosity Linear porosity	B ($A \leq 1\%$)		C ($A \leq 2\%$) ^a		D ($A \leq 4\%$)
3	2017	7	Surface pores	Not permissible		B		C
4	2013	6	Clustered porosity	B		C		D
5	2015 2016	None	Elongated cavity Worm- hole	Not permissible		$h \leq 0,3$ a res. $0,3$ s $l \leq a$ res. s ^b		Only short irregularities permissible $h \leq 0,4$ a res. $0,4$ s
6	300	8	Solid inclusion	B		B		C
7	3041	9	Tungsten inclusion	Not permissible		B ($l \leq a$ res. s)		C
8	3042	10	Copper inclusion	B		B		C
9	401	11	Lack of fusion	B		B		C
10	402 402	12 12.1	Lack of penetration (also for Y- and HY- seam) Lack of penetration (Fillet weld)	B		B (the set value of penetration must be achieved)		C
11	617	13	Incorrect root gap for fillet welds	Not applicable		B (front length edge at fillet welds to seize firmly)		C
12	5011 5012	14 14	Continuous undercut Intermittent undercut	Not applicable		Only short irregularities permissible $h \leq 0,1 t \leq 0,5$ mm ^c		C
13	502 503	15 16	Seam super elevation at Excess weld metal Excessive convexity	B (max 3 mm)		C ($l \leq 3$ mm local excess permissible)		D (at ≤ 3 mm local excess permissible)
14	5214	17	Excessive throat thickness	Not applicable		C ($l \leq 3$ mm local excess permissible)		D (at ≤ 3 mm local excess permissible)
15	5213	18	Insufficient throat thickness	Not applicable		C (to ≤ 100 mm reference length is a_{nom} to be achieved centrally)		C

Table 4 (continued)

Ser. No	Order No. to DIN EN ISO 6520-1	No. to DIN EN 30042	Irregularities Description	Welding quality classes						
				1	2.1	2.2	2.3	3		
Validity groups to DIN EN 30042; Deviations										
16	504 5041	19 None	Excess penetration Local excess penetration (only butt weld)	B (only with soft transition by grinding back up or backing run)		C		C		
17	507	20	Linear misalignment	B		C		D		
18	511	21	Incompletely filled groove	B		C		D		
19	512	22	Excessive asymmetry of fillet weld	Not applicable		C		D		
20	515 5013	23 23	Root concavity Shrinkage groove (butt weld)	Not permissible	Only short irregularities permissible $h \leq 0,1$ $t \leq 0,5$ mm			C		
21	506	None	Overlap		Not permissible					
22	2025	None	End crater pipe	Not permissible	$h \leq 0,5$ mm (without sharp transitions)		Permissible			
23	517	None	Poor restart		Not permissible					
24	601	None	Stray arc		Outside welding gap not permissible					
25	602	None	Spatter	Not permissible	Not permissible for parts with paint, outside painted surfaces occasionally permitted					
26	-	24	Multiple irregularities:							
			Various irregularities a) Sum of pores, porosity, gas channel, hose pore, worm hole and all firm inclusions (No. 3 -10 to DIN EN 30042) b) Sum of other irregularities	A \leq 1 %		A \leq 2 %		A \leq 4 %		
					on projection area of the X-ray picture or fracture area					
				Not permissible	On 100 mm reference length the remaining net area of any length section must be at least 95% of the rated area		B			
<p>a A = area of irregularity pro 100 mm seam length b l = length of irregularity; a = rated measure of fillet seam thickness; s = nominal size of butt weld thickness c h = size of irregularity;</p>										

Note: HV- and DHV- welding seams on T-Joints are butt welds

6.1.1.2.4 Laser beam and electron beam welded joints

According to the respective welding quality seam class for laser beam and electron beam welded joints the requirements to DIN EN ISO 13919 are as follows:

- welding seam quality class (SGK) 1: Validity group B (undercuts are not permissible)
- welding seam quality class (SGK) 2.1 to 2.3: Validity group B
- Welding seam quality class (SGK) 3. Validity group C

6.1.1.2.5 Gas fusion welding joints

For gas fusion welding joints the requirements according to arc welding fusion welding joints have to be applied to **table 3**.

6.1.2 Stud welding

The measures for stud welding are only admissible for welding quality classes 2.3 and 3.

According to the welding seam quality the general requirements are valid as well as the test tent and the quality requirements of **table 5**.

Table 5: General requirements and tests for stud welding joints

Welding seam quality class	SGK 2.3	SGK 3
Area of application	panelling and attached parts for inside and outside areas	Studs for subordinate part for inside construction (for instance securing cable clamps)
Welding process	drawn arc stud welding: 3 to 12 mm diam. capacitor discharge stud welding with tip ignition: 3 to 8 mm diam.	
Weldable materials	acc. to DIN EN ISO 14555, item 4.3 to 4.6, including table 2 to 5 and item 7.25	
Quality requirements for		
• - Visual test	The form, size and evenness of the welding reinforcement are to be assessed acc. to DIN EN ISO 14555 table 6 to 8	
• Penetration test ^a (PT)	Undercuts not permissible	Minor undercuts permissible
• Bend test	No incipient cracks up to bending angle 60° resp. 30° in the welding joint acc. to DIN EN ISO 14555, table 10	
• Macrograph	Acc. to DIN EN ISO 14555, table 11	Inapplicable
Test extent	-100 % visual test -NAP ^b for approve the WPS- -VAP ^c - before works starts - change of WPS - change of tools	-100 % visual test -VAP ^c -before works starts -change of tools
Documentation	NAP + VAP acc. To DIN EN ISO 14555, item 10.6	Inapplicable

^a PT-test to be carried out if in SGK 2.3, if the stud is not fully enclosed by welding reinforcement.

^b NAP = normal works test: visual test, macrograph, bend test acc. to DIN EN ISO 14555, table 10

^c VAP = simplified works test: visual test, bend test acc. to DIN EN ISO 14555, table 10

6.2 Resistance welding joints

6.2.1 Resistance spot-projection and roller seam welding joints

6.2.1.1 Quality requirements

The quality requirements for welding joints, which are manufactured by way of resistance spot (RP)-projection (RB) and roller (RR) seam welding can be found in **table 6**.

The surface quality of the welding joint is defined in **table 7**.

Table 6: Quality requirements for resistance spot-projection- and roller seam joints

Ser. No.	Order No. to DIN EN ISO 6520-2	Requirements	SGK 2.1	SGK 2.3	SGK 3.
Quality requirements, general					
1		Classification of welding processes	RP, RR	RP, RB, RR	
2		Sort of machine	Welding machines with programme cycle control and process inspection	Welding machine with programme cycle	The requirements SGK 2.1 and 2.3 are valid for RP the use of manual, foot table machines permissible.
3		Area of application	Supporting part of rail vehicles (side walls, front walls, floors and outside parts as instrument cases, flaps, aprons, doors)		Subordinates parts (panels, cable ducts, ventilation grids)
4		Permissible sheet metal thickness proportion	$t_2 : t_1 \leq 3 : 1$ Other sheet metals proportions and welding of more than two sheets must be agreed with customer		No requirements
5		Minimum shear pulling force	For RP table 8 and 9 For RB and RR these table are valid in the sense corresponding to the connecting sector		75 % of SGK 2.1 / 2.3
6		Quality factor Q	1,0	0,9	0,75
7		Surface appearance of the various parts	The surface of the joined parts must be free of scale, rust, paint, dust, grease or other soiling at the place of the weld. Additionally surface coatings, lamination, corrosion protective, sealing, pastes and glue can be used if their wholesomeness to the welding suitability has been proved.		
8		Maximum hardness values	See DIN 6700-4 pt. 5.1.3 and 5.2.2 acc. to DIN EN 288-3		No requirements
Quality requirements outer findings, external					
9	P 100	Crack	Not permissible		
10	P 2011 P 2012 P 2013	Gas pore Uniformly distributed porosity Localist porosity	Not permissible		Permissible in isolated cases
11	P 602 P 612	Spatter Material extrusion	Permissible in isolated cases		Permissible sometimes (low)
12	P 526	Surface imperfection	Surface quality 2 and 3 to table 7 permissible		Surface quality 2, 3 and 4 to table 7 permissible
13	P 522	Burn through from one side	Not permissible		Permissible
14	P 5263	Adhering electrode material	Not permissible		Permissible in certain cases

Table 6 (continued)

Ser. No.	Order No. to DIN EN ISO 6520-2	Requirements	SGK 2.1	SGK 2.3	
Quality requirements, inner findings, internal					
15	P 5216	Insufficient depth of penetration of nugget	Min. 30 % max 90% of the particular sheet metal thickness	No requirements	
16	P 100	Crack	Permissible for RP and RB in the middle half of the welding lens diameter. Not permissible for RR		
17	P 2011 P 300	Gas pore Solid material inclusion	Permissible for RP and RB in the middle half of the welding lens diameter.		
18	P 2012 P 2013	Uniformly distributed porosity Localist porosity	For RR: $A \leq 2\% \quad h \leq 0,4 t_1$ ^a	For RR: $A \leq 4\% \quad h \leq 0,5 t_1$	
19	P 400 P 401	Lack of fusion No weld	Not permissible		
20	P 525	Excessive sheet separation	Immediate next to the welding point: $h \leq 0,1 (t_1 + t_2)$	permissible	
Testing and documentation					
21		Visual test	100 %	100 %	
22		Simplified works test (VAP) ^c	- daily before start of work - at change of the WPS - at tool modification		
23		Normal works test (NAP) ^d	- For the prove of the WPS - To prove the quality in the production at regular intervals in dependence on weld volume, weld equipment and welding quality class	Not required	
24		Documentation	- NAP 100 % Process inspection.100 %	- NAP necessary	Not required

^a A = Area of unevenness; h = size of single unevenness (for instance length, width, diameter)

^b Testing the completeness of welding and external assessment without use of optical instruments

^c VAP: Rolling-, chipping- (to DIN ISO 10447) or simplified torsion test to E DIN 32518-2 (Work test)

^d NAP: for RP and RB: Shearpullingtest to DIN 50124, macrograph
for RR: NDT, Shearpullingtest to DIN 50124, macrograph

Table 7: Surface quality for Resistance spot-projection- and roller seam welding seam joints

Surface quality	Requirements	Application
1	Is to be agreed between manufacturer and customer	Is to be agreed between manufacturer and customer
2	Surfaces, where welding marks (electrode impressions, ringformed reinforcement-formation, unevenness, through heat distortion etc.) does not amount to more than 10% of the particular single sheet metal thickness. Note: if required the indentation can be filled in.	For surfaces with decorative requirements (for instance side walls, front walls and roofs of passenger trains)
3	Surfaces where welding marks do not amount to more than 25 % of the particular metal thickness. In this area are also firmly adhering welding spatter permitted as long as the drawing does not demand that it must be free of burrs and splatters	Surfaces for non-decorative requirement (for instance freight wagons trains, transport containers, sheeting of floors)
4	Without Quality requirements	For simple parts of subordinate importance without decorative requirements

6.2.1.2 Minimum shear pull forces

The following tables contain the minimums hear pull forces for resistance spot welding joints in dependency of metal thickness for welding quality 2.1. and 2.3 prove in the tensile shear test.

- steel: table 8
- Aluminium – and alloys: table 9

Note:

1. The given values are the minimum central values about minimum one row of spot welds.
2. Higher shear pull forces are after present day techniques possible. For the dimension they must be approved by tests and prior to prduction by way of work tests.
3. If the values will not reached in preliminary tests, the production requirements have to be tested.
4. Principle the demand quality as shown in table 6 must prove during the production.

Table 8: Minimum shear pull forces for resistance spot welding joints of steel for welding seam classes 2.1 and 2.3

t_1 [mm]	d_L [mm]	Minimum shear pull force per point [kN]		
		Rm parent metal [Mpa]		
		①	②	③
		270 to < 360	360 to < 510	510 to < 620
0,8	4,5	3,5	4,5	6,0
1,0	5,0	4,7	6,0	8,0
1,25	5,5	5,9	7,5	10,0
1,5	6,0	7,1	9,0	12,0
1,75	6,5	8,5	10,9	14,5
2,0	7,0	10,0	12,8	17,0
2,5	8,0	12,9	16,5	22,0
3,0	8,5	16,5	21,0	28,0

These values be valid for unalloyed and alloyed steel, also for the combination of them. For the combination of parent metals with different tensile strength, the materiel with the lower value has to been chosen.

Table 9: Minimum shear pull force for resistance spot welding joints of aluminium and – alloys for the welding seam quality classes 2.1 and 2.3

t_1 [mm]	d_L [mm]	Material shear pull force per point [kN]		
		Rm parent metal [Mpa]		
		①	②	③
		190 to 240	> 240 to 300	> 300 to 350
0,8	4,5	1,1	1,3	1,5
1,0	5,0	1,5	1,8	2,1
1,25	5,5	2,0	2,3	2,8
1,5	6,0	2,5	2,9	3,5
2,0	7,0	3,5	4,1	4,8
2,5	8,0	4,5	5,3	6,2
3,0	8,5	5,5	6,4	7,6

For parent metals with different tensile strength, the materiel with the lower value has to been chosen.

6.2.2 Foil seam welding

The quality requirements for Foil seam welded joints are to be gathered from table 10

Table 10: Quality requirements for foil seam welding of steel

Ser. No.	Order No. to DIN EN ISO 6520-1 a	No. To. DIN EN 25817	Irregularities	Validity groups to DIN EN 25817 Deviations		
				SKG 2.1	SGK 2.3	SGK 3
Quality requirements, general						
1			Area of application	Main supporting load-bearing parts of railvehicles (i.e. sidewalk, frontwall, roofs, floors) and outside groups (i.e. instrument boxes, doors, aprons, flaps)	Subsidiary parts (i.e. panelling cable channel products)	
2			Surface condition in the weld seam area	The surface of the joined parts must be free of scale, paint, dust, fat and other impurities in the area to be welded		
3			Width of gap	$b \leq 0,3 \text{ mm}$		
4			Work surface in welding joint	Right angle and burr free		
5			Metal thickness difference in welding joints	$\leq 0,2 \text{ mm}$		
Quality requirements, external result						
6	100 104	1 2	Crack Crater crack	C		
7	-	11	Notch - in the welding foil across and along to the weld seam - in transition weld to basic material	Only short irregularities admissible $h \leq 0,1 t$, max. 0,5 mm ^b	C	
8	-	-	Seam attachment fault Seam run out fault	Not permissible ^c		$h \leq 0,1 t$ ^b
9	-	-	Adhering electrode material	Not permissible		Permissible in certain cases

Table 10 (continued)

Ser. No.	Order No. to DIN EN ISO 6520-1	No. To. DIN EN 25817	Irregularities	Validity groups to DIN EN 25817 Deviations		
				SKG 2.1	SGK 2.3	SGK 3
Quality requirements, internal results						
10	2011 2012 2014 2017	3 3 3 3	Gas pore Uniformly distributed porosity Linear porosity Surface porosity	B		C
11	2013	4	Clustered porosity	B		C
12	2015 2016	5 5	Elongated cavity Worm- hole	B ($l \leq t$) ^b		C
13	300	6	Solid inclusions	B		C
14	401	8	Lack of fusion	B		D Large irregularities not permitted
15	-	-	Multiple irregularities (Ser. Nr. 10 - 13)	$A \leq 2\%b$		$A \leq 4\%b$
Testing and documentation						
17			Visual test	100 %		
18			Non-destructive test (NDT) ^d	100 % ^e	No requirements	
19			Simplified work test (VAP) ^f	- daily before starts of work - at change of WPS - after roller electrode change		
20			Normal work test (NAP) ^g	To prove WPS		Not required
21			Documentation	necessary		Not required
a	Because character of seam order numbers next to fusion welding			e	By process inspection 10 %	
b	A = area of irregularities; h = heights of irregularities; l = lengths of irregularities			f	Bending test / folding test (Work test)	
c	Start and run out metal recommended			g	Tensile test acc. to DIN EN 895, bend test acc. to DIN EN 288-3; NDT; Macrograph	
d	NDT = X- ray test (RT)					

6.2.3 Flash butt welding joints

The quality requirements for RA-welding joints of steel in depend of the welding seam class are to be taken from table 11.

For aluminium and other NE-metals the quality requirements are to be applied correspondingly.

Table 13: Quality requirements for Flash-butt-welding joints on steel

Ser. No.	Order No. to DIN EN ISO 6520-2	Irregularities	Welding seam quality (SGK)					
			1	2.1	2.3	3		
Quality requirements, general								
1		Machine sort	Welding machine with programme cycle control and process inspection		Welding machine with programme cycle control			
2		Area of application	Parts with special requirements	Parts with medium to high requirements (for instance pull and push equipment, brake drew bar, brake cress beams)	Parts for medium and low requirements (seat racks, crank)			
3		Preparation of workpiece	The clamping and butt joints places must be free of paint, dirt, oil, grease, rsut and scale. The butt joint areas should be parallel without misalignment vertical to upset welding direction. When welding flash from cold both butt weld areas can be chamfered at an angel from 5 to 20°					
4		Difference of cross values	≤ 8 %	≤ 15 %	≤ 20 %			
5		hardness values	acc. to DIN EN 288-3			No requirements		
Quality requirements, external								
6	P 100	Crack	Not permissible					
7	P 502	Too large seam elevation (upset reinforcement treatment)	Treated in direction of stress.	Treated in direction of stress. $h \leq 0,5 \text{ mm}$	According to purpose of usage			
8	P 507	Misalignment of edges	$h \leq 0,08 \text{ t} \leq 1 \text{ mm}$	$h \leq 0,15 \text{ t} \leq 2 \text{ mm}$	$h \leq 0,2 \text{ t} \leq 4 \text{ mm}$			
9	P 501	Notch	Not permissible	only short unevenness $h \leq 0,1 \text{ t} \leq 0,5 \text{ mm}$	$h \leq 1,0 \text{ mm}$			
Quality requirements, internal								
10	P 100	Crack	Not permissible					
11	P 400	Lack of fusion	Not permissible					
12	None	Cavities and solid material inclusions	$A \leq 2 \% a$ $h \leq 0,1 \text{ t} \leq 2 \text{ mm}$	$A \leq 4 \% a$ $h \leq 0,2 \text{ t} \leq 3 \text{ mm}$	$A \leq 8 \% a$ $h \leq 0,4 \text{ t} \leq 3 \text{ mm}$			

Ser. No.	Order No. to DIN EN ISO 6520-2	Irregularities	Welding seam quality (SGK)				
			1	2.1	2.3	3	
Test and documentation							
13		Visual test	100 %				
14		NDT	Surface – crack test	100 %		Not required	
			Supersonic Test b	100 %	100 % c	10 % d	
15		Simplified work test (VAP) e	<ul style="list-style-type: none"> - after modification of tools and change of material - after overhaul on machine - after agreed batch amount 				
16		Normal work test (NAP) f	To prove of WPS			Not required	
17		Documentation 7)	Required				
a	h = Size of individual unevenness (for instant length, width, diameter); A = area of unevenness			d	Not applicable for documentation		
b	Can be replaced in individual case by X-ray test			e	VAP: Notched bar bending test, fracture area evaluation or NDT		
c	For documentation of the welding parameter (required are strength of the electric current power and movement about welding clearance time 10%) In accordance this test can be replaced by picetests.			f	NAP: Tensile test to DIN EN 895; bending test to DIN 50121-2; Macrograph, hardening test, NDT		
				g	Documentation of welding parameter respectively the results of NDT		

6.3 Other welding joints

For welding joints manufactured by other welding procedures the procedures of this norm can be applied accordingly. For this the requirements have to be agreed between manufacturer and client.